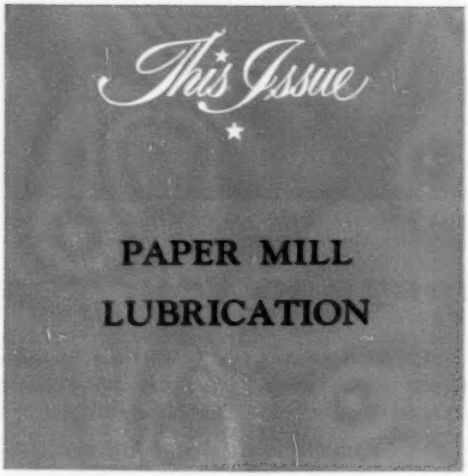
Volume 44 APRIL, 1958 Number 4

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants



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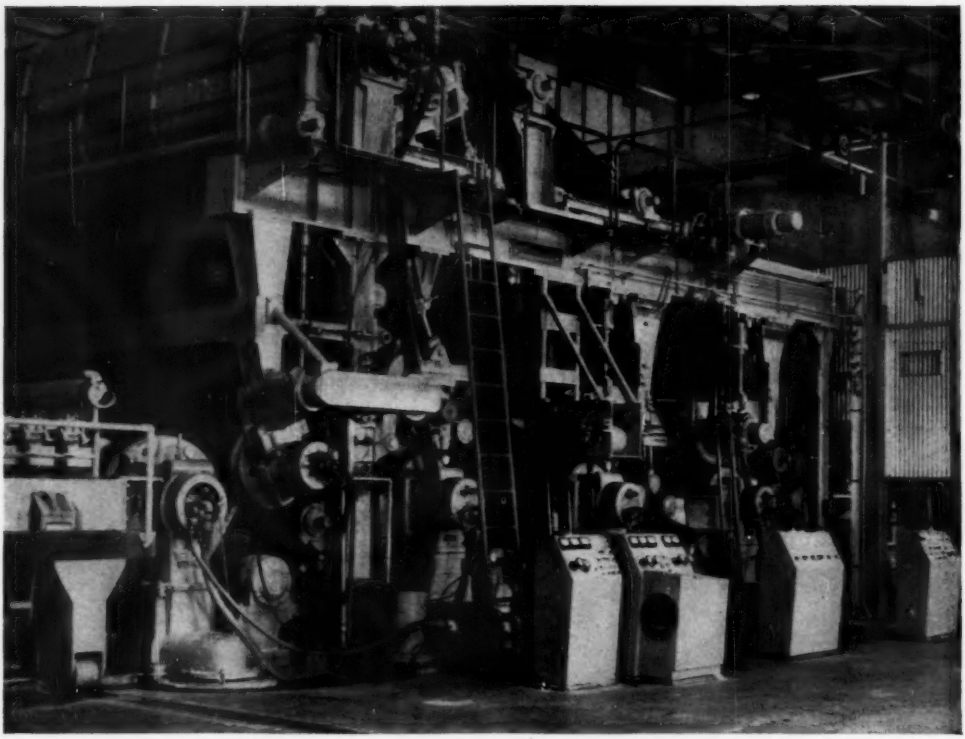

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Paper Mill Lubrication

In an era that has been highlighted by tremendous advances in mechanical developments along all fronts that affect our national economy and an easier way of life, the petroleum industry can take considerable pride in its contribution to these achievements. During the past fifty years, industry's equipment has been designed to run faster at higher temperatures, loads, and pressures. This has not only necessitated mechanical design changes, but also the use of improved lubricants and lubrication procedures which minimize mechanical difficulties under the more severe operating conditions. Success must be attributed to the excellent cooperation of all concerned, — the machine designer, machine operator, and lubricant supplier.

The paper industry enjoys an enviable position with an ever increasing contribution to our present mode of living. It is the third fastest growing industry in the country today and has perhaps contributed more to our present civilization than any other. We would still be in the dark ages were it not for the manufacture of ample supplies of paper for the printing of the textbooks on science, medicine, and philosophies which form the framework of our present better way of living, and the newspapers which appraise us daily of the happenings over an active world.

Paper manufacture had its origin over two thousand years ago in China but it is questionable whether Ts ai Lun could have possibly visualized the large variety of papers and manufacturing techniques which would ensue as a result of his invention. Strange as it may seem, the basic principle of manufacture has remained the same. For centuries, the sole outlet for paper was for writing and printing. The versatility of paper was not fully realized until recent years, and the industry received an impetus by the manufacture of a number of products for other uses. Illustrative of these are kraft, boxboard, tissue, glassine, etc. There will be others. Figure 1 shows the consumption of paper and paperboard in the United States since the start of the century with estimated requirements to 1970. The large part of the indicated increase in total production will come from the South due to the availability of large quantities of pine and the comparatively short period required to grow new trees. Hidden in Figure 1 is an increased number of new mills and modernized older ones, operating at higher temperatures and speeds, and requiring new oils and greases to provide better lubrication and insure a minimum downtime for maintenance and replacement parts.

The manufacture of paper is essentially a chemical process in which crude cellulose materials are both physically and chemically processed to remove undesirable constituents, admixed with chemicals which impart desired characteristics, and finally

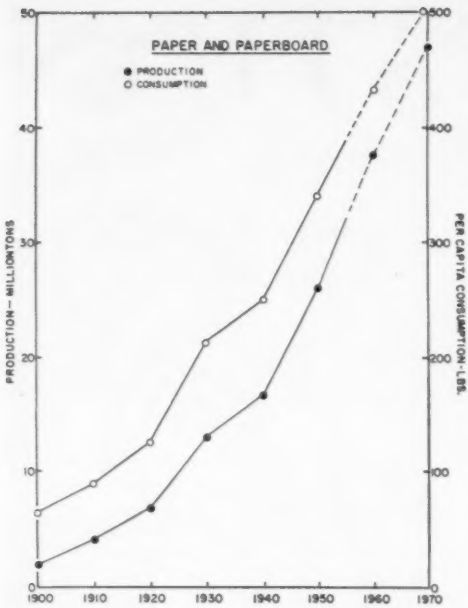


Figure 1 — Production and consumption of paper and paperboard.

felted from dilute water slurries and dried to form the paper. There are a large number of natural sources of cellulose which have been used for paper manufacture but wood is the only one of major significance in today's operations. The greater percentage of our paper is made from soft woods, such as pine and spruce, but a sizeable amount is obtained from hardwoods. There are three basic chemical processes in the paper industry, namely the *"sulfite," "sulphate,"* and *"soda"* processes.

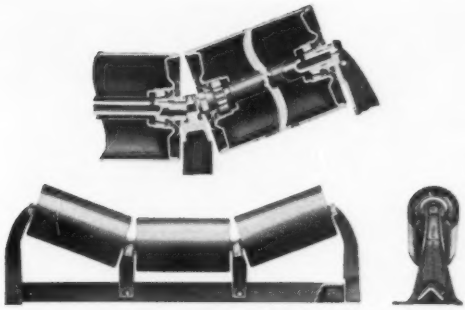
In spite of the fact that paper making is fundamentally chemical in nature, it is dependent upon mechanical equipment at each step in the processing to insure continuous production of a uniform product. Fortunately, this equipment is largely independent of the raw material used and the method of processing. This greatly simplifies the problems of the lubrication engineer who has the responsibility of keeping all the equipment operating with minimum shutdowns, which contributes to low production costs. This is important as the value assessed against downtime for modern high speed machines during a period of equalized product demand and production ranges from three to eight thousand dollars an hour and is much greater than in the past.

The manufacturers of paper machines and the auxiliary equipment found in paper mills have done their job well. This is manifested by the fact that some fifty-year old units continue to operate alongside of their modern counterparts. In many cases, these older units have been modernized as much as is practical and are currently operating at many times their original design capacity. This situation often results in a number of different style bearings and methods of lubricant application and may require more than the normal number of products to insure economical lubrication. Lubrication recommendations for the same or comparable pieces of paper mill equipment cannot be stereotyped due to the variations in temperature and moisture conditions under which they operate. This is especially applicable to all outdoor wood handling operations up to and including the chippers. Equipment in the northern mills which is exposed to snow and subzero temperatures will require radically different lubricants than the same equipment operating under less severe conditions in the South. During the past fifteen years, the petroleum industry has developed lubricants for use under adverse temperature and moisture conditions. These developments have minimized many of the lubrication problems on paper mill equipment operating under difficult conditions.

Any integrated operation as large as that found in our modern paper mills is dependent upon sound design to furnish a continuing and adequate supply of material to succeeding phases of the process. This requires a minimum downtime on hundreds of individual mechanical units with thousands of bearings and gears which demand proper application of correct lubricants to insure against shutdowns due to lubrication difficulties or corrosion. It is not too difficult to select proper lubricants for the equipment involved but the frequency of application will vary considerably due to age of the equipment and efficiency of those responsible for this phase of the operation. The equipment used in each step of paper manufacture is associated with water and it can be expected that water will contaminate the lubricants

Courtesy of Jeffrey Mfg. Co.

Figure 2 — Woodpile stacking conveyor.



Courtesy of Jeffrey Mfg. Co.

Figure 3 — Conveyor belt idler rolls.

to a varying degree. This necessitates the selection of lubricants which can tolerate water contamination by continuing to prevent rusting and corrosion while providing satisfactory lubrication.

Lubrication in a paper mill is an around-the-clock operation and must be simplified as far as possible to insure optimum results at a minimum maintenance cost. The reduction of the number of lubricants to a minimum is the most important factor contributing to lubrication economy and low maintenance costs. This dictates the selection of premium lubricants and has the following advantages:

(1) Best possible lubrication at all points
(2) Lower labor costs
(3) Lower lubricant inventory and storage facilities
(4) Less possibility of wrong lubricant application
(5) More dependable inventory maintenance by plant and supplier

A general description of the equipment used in the successive steps of paper manufacture and general lubrication requirements are as follows:

WOODYARD

Wood for paper manufacture is delivered to the paper mill in greatly varying diameters and lengths depending on both the wood growth and means of transportation. In those areas where truck or rail transportation is used, the logs are normally cut into six-foot lengths in the woods. Arriving at the woodyard, they are transported by means of belt conveyors to desired locations where they are stacked or piled by means of stackers for future use as illustrated in Figure 2. Those mills, strategically located on lakes or rivers, process uncut logs floated into the mill.

Transportation of logs in the woodyard is by electrically driven belt conveyors which are hundreds of feet long. The belts ride on idler rolls like those illustrated in Figure 3 which are spaced at a few feet apart. In northern mills, conveyor belts may present a problem of high starting torque during cold weather. Three factors may contribute to this condition: (1) belt frozen to the idler rolls, (2) grease in idler roll bearings frozen as a result of water contamination, and (3) the use of a grease which stiffens excessively at low temperature. Proper protection and maintenance will eliminate the first two of these contributing causes while the selection of a grease designed for low temperature operations will eliminate the last cause. Where idler rolls are oil lubricated, it is necessary to use an oil having a pour point below the minimum ambient temperature but with a sufficiently high viscosity to prevent excessive leakage.

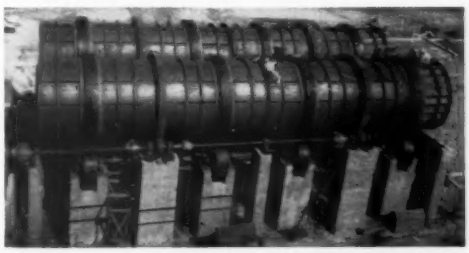
There are several uses for chain conveyors in woodyard operations but there is usually enough water present to effect whatever lubrication is necessary. Where additional lubrication is required, the use of a straight mineral oil applied by drip or wick feeding is adequate.

BARKERS

The initial step in the manufacture of paper from logs is the removal of the bark. This is essential as bark does not respond to subsequent chemical treatment and the presence of even small quantities would detract from the quality of the finished sheet. There are several debarking procedures — chemical, mechanical, and hydraulic.

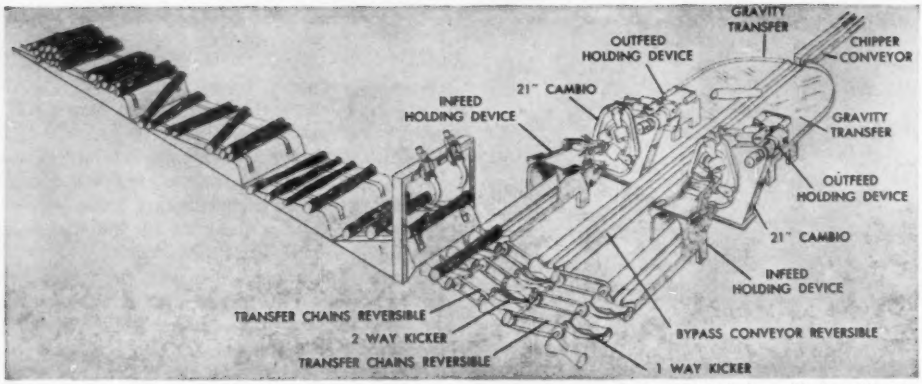
In order to eliminate debarking at the pulp mills, a chemical debarking procedure is being developed to remove the bark from the trees before they are felled in the woods. It consists of removing the bark from a narrow ring around the tree and painting the underlying sapwood with a sodium arsenite solution. This procedure loosens the bark in a short period to a variable extent depending on the species of tree. This process is still experimental.

While there are a number of different types of mechanical barkers, the drum barker like the two illustrated in Figure 4 is the most popular in large mills due to its wood saving and ability to handle different length logs. The drum barkers are open-



Courtesy of Carthage Machine Co.

Figure 4 — Drum barkers.



Courtesy of Soderhamn Machine Mfg. Co.

Figure 5 — Rotating-knife type twin debarkers.

ended cylindrical shells approximately sixteen feet in diameter and forty feet long and fabricated from heavy channel iron. The drums are mounted at a slight angle to the horizontal and revolve slowly and operate with wood being fed into the higher end and discharging from the lower end. The cylinders are maintained two-thirds full of logs, and bark removal results from the friction and pounding of adjacent logs in their passage through the drum.

There are two general methods of mounting these drums and each calls for a different type of driving mechanism with variation in lubrication requirements. In some cases, the drums are placed on multiple trunnion mountings with anti-friction pillow block bearings and are electrically driven through a gear reducer to a large girth gear. The open gears are satisfactorily hand-lubricated with heavy gear oils designed to have sufficient adhesiveness to insure their staying on the gear surfaces, and mild extreme pressure characteristics to reduce wear. Modern trunnion bearings are of the double roller self-aligning type designed to withstand the high loads and rough usage to which they are subjected. These are generally grease lubricated and a relatively soft, water resistant grease, having high load carrying capacity, is recommended due to the continual exposure of the bearings to water and unfavorable weather conditions.

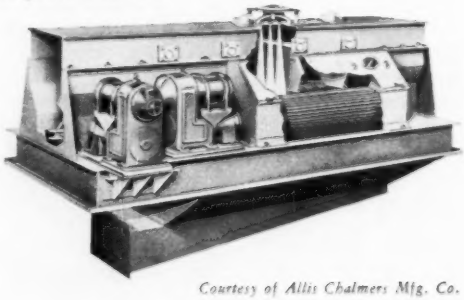
An alternate method of barking drum installation involves suspending it from an overhead frame by means of heavy chains. The drum is driven by means of a motor, located on top of the frame, through a suitable gear reduction to a chain which encircles the drum on a sprocket. In this type of driving mechanism, the chain drives and open gears as well as the plain bearings of the reduction gears and drum guides should be lubricated with the same type of product recommended for the trunnion-mounted drum.

The same debarking action takes place in single or multiple-pocket debarkers which operate either batch wise or continuously. These are less adaptable than the drum barkers as they require uniform length logs.

The logs discharging from the barking drums are carefully inspected and those containing more than a small amount of bark are recycled through the drum. The clean logs are conveyed to either a grinder or chipper, for reduction to the proper size for subsequent processing, depending on the type of paper being manufactured.

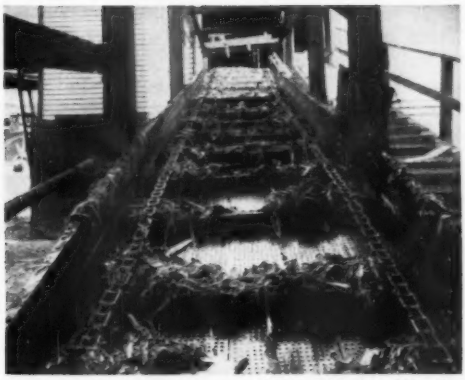
Long, large diameter logs may be debarked singly by putting them through barking machines like those shown in Figure 5 in which high speed adjustable, rotating, curved knives strip off the bark. Logs which are too large for the machine are first cut into "cants."

As illustrated in Figure 6 logs may also be debarked hydraulically by impinging jets of water or steam under high pressure upon the log surface as it is caused to rotate and move forward by spiral bed rolls. Figure 7 illustrates a conveyor transferring bark to the boiler house where it will be burned to provide steam.



Courtesy of Allis Chalmers Mfg. Co.

Figure 6 — Hydraulic debarker.



Courtesy of Jeffrey Mfg. Co.

Figure 7 – Bark Conveyor.

CHIPPERS

All the debarked logs for kraft manufacture and a high percentage of those to be used for newsprint are moved by conveyors to chippers which cut them into small chips that readily respond to subsequent chemical action in the digesters. The chipper is of a simple but rugged constructon. It consists of a round, solid iron disc having a diameter as large as nine feet and a normal thickness of four inches with from four to twelve sets of knives placed radially on one side. The disc is mounted on a large horizontal shaft supported by anti-friction bearings. The logs are fed through an inclined spout at an angle of forty-five degrees to the cutting side of the disc. A chipper disc weighs approximately three tons, is electrically driven at speeds of 300-600 RPM and is so powerful that it will reduce an eight-foot log eight inches in diameter to chips in less than two seconds. Chippers are subjected to severe shock loading and pounding, and lubricants must be selected which provide bearing protection under these conditions. The chipper bearings are oil-bath lubricated and the use of a mild extreme pressure oil is essential. The grease-lubricated shaft bearings require a relatively soft water-resistant calcium or lithium soap grease.

The chips produced are classified on an oscillating screen and the oversized ones are sent to a rechipper for further reduction in size. Those of proper size are carried by conveyors to the chip storage bins on top of the digesters as shown in Figure 8.

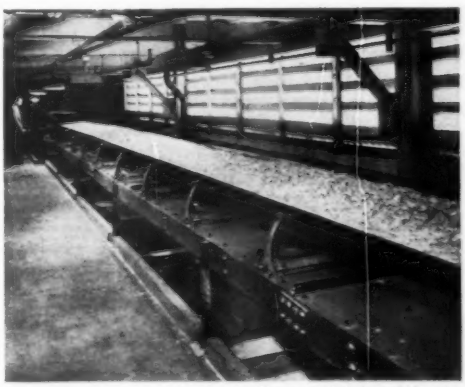
DIGESTERS

The conventional digester is a vertical tank approximately 15 feet in diameter and 50 feet high made of heavy gage steel with a corrosion resistant liner. A digester of this size will handle 22 cords of chipped wood which are charged to the unit through a top manway. The chips are cooked at 70 p.s.i. steam pressure with 28,000 gallons of acid for a period of seven hours to disintegrate the chips into fibers and to remove all dark colored resinous and lignin materials. After chemical treatment in the digesters and subsequent removal of chemicals in the blow-pits, the pulp is subjected to a series of screening operations for the removal of any remaining fiber clusters, knots and slivers.

GRINDERS

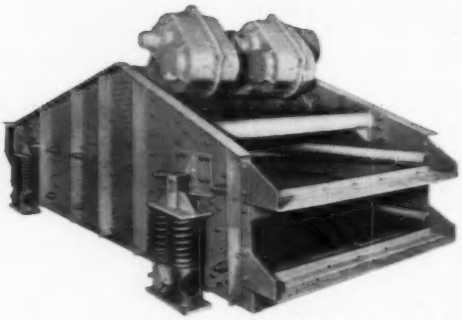
A large percentage of the paper used today is required to give very limited service before it is destroyed, consequently it does not have to be of very high quality. The best example of this is newsprint. These papers contain high percentages of groundwood which is obtained by running debarked logs under pressure against a revolving stone. This groundwood receives no subsequent chemical treatment but is mixed with varying percentages of chemical pulps to impart desired properties to the resulting paper.

The logs from the barking drums are charged to the grinders which vary considerably in design but all work on the same general principle. These units consist essentially of a grinding stone having a diameter of 54 to 62 inches and a width sufficient to accommodate four-foot logs. The stone is mounted on a large horizontal shaft and revolves within a steel housing having from two to four "pockets" each of which holds several logs whose sides are forced against the grinding stone by hydraulically driven piston heads in the top of the pockets. Artificial grindstones made of silicon carbide and similar abrasives are replacing natural stones due to their greater uniformity. The developments in grinder design have been directed toward greater production and has resulted in semi-automatic magazine type grinders and finally continuous grinders. The grinding operation is carried out under a full



Courtesy of Jeffrey Mfg. Co.

Figure 8 – Chip Conveyor.



Courtesy of Allis Chalmers Mfg. Co.

Figure 9 — Double-deck low head screen.

stream of water for the twofold purpose of reducing the temperature and cleaning the grinding surface of the stone.

The grinders in use today vary greatly in size and capacity, and their design provides for different types of bearing lubrication. The earlier machines usually were provided with ring-oiled plain bearings and were lubricated satisfactorily with straight mineral oils. Some older machines had bearings equipped with recessed cups requiring the use of greases or oiled waste. As grinders have increased in size, there has been a tendency toward oil-lubricated anti-friction roller bearings. The lubrication of grinder bearings, especially the roller bearings, frequently presents a problem due to water and/or pulp being forced through the packing and into the bearing housings. This not only impairs lubrication but may result in bearing corrosion. This difficulty can be minimized by resorting to the use of higher viscosity lubricants. In the case of roller bearings which are subjected to greater pressures, wear and corrosion due to a slight water leakage can be eliminated by the use of oils with minimum water sensitivity. It is important that grinding operations be carried out with a true running stone. Vibration and slight misalignment will manifest itself in the quality of the groundwood and final sheet. The lubricants must insure against bearing wear and failure under high loads and the presence of water.

SCREENS

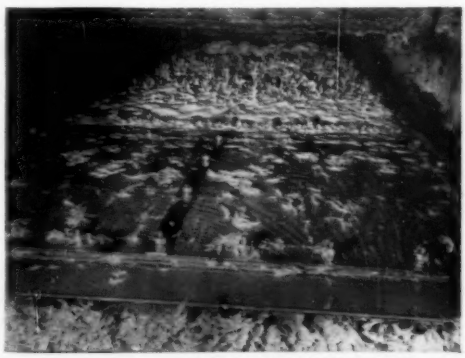
Screening is a very important operation in the production of all types of paper products. As previously indicated the first screen installation follows the chipper where oversized chips are separated and sent to a rechipper for further reduction. Unbleached stock from the digesters and groundwood from the grinders contain an appreciable percentage of material that would be detrimental to the finished paper and which must be removed by screening. These are knots, shives, dirt, and slivers. The stocks are subjected to both coarse ("bull") and fine screening. There are a number of different screens being used in this service but they can be grouped into two classifications. Those used for knotting and coarse screening are of the flat tray design like that shown in Figure 9 and have an oscillating high frequency vibrating action. Figure 10 shows the effect of vibration on the fibrous stock. Another type of equipment is illustrated in Figure 11. The fine screening is conducted in cylindrical drums with fine slots on the surface which permit passage of the desired fibers while the drum revolves — and sometimes vibrates. In both types of screens, grease lubricated anti-friction bearings are used and relatively soft water-resistant greases should be used. This is also applicable to the eccentric bearings. Mild extreme pressure oils are required in the gear drives.

WET MACHINES AND DECKERS

The stock from the fine screens is then thickened in *wet machines* or *deckers*, depending on the mill's immediate requirement for pulp. These units are similar in nature and consist of a large wire-covered horizontal cylinder revolving in a vat of stock. Water removal is accomplished by vacuum inside the drum. In the case of the *decker*, the partially dehydrated stock is removed by a doctor blade from a couch roll located on top of the cylinder. The "deckered" stock falls into a chest for further processing by the *refiners* and *jordans*. The *wet machine* works on the same principle but removes sufficient water to form a sheet ("lap") which can be folded several times for storage and future use or for shipment to other mills. The wet machine cylinder is supported on grease lubricated anti-friction bearings lubricated with calcium or lithium soap greases. Lead soap gear lubricants are recommended for the gear cases.

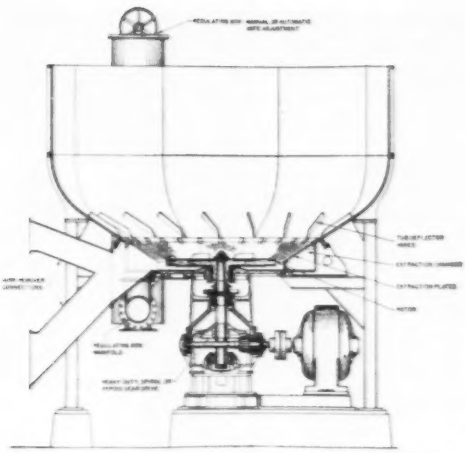
BLEACHING

Wood pulp invariably contains small amounts of



Courtesy of Allis Chalmers Mfg. Co.

Figure 10 — Fibre motion on screen.



Courtesy of Black-Clawson Co.

Figure 11 — "Hydropulper" repulper.

colored lignin products and must be bleached if it is to be used for the finer grades of light-colored papers. Bleaching is a chemical process performed continuously in present practice as compared to the earlier batch procedure. Several bleaching procedures are used employing different chemicals, a multiplicity of equipment designs, and methods of chemical application. With the exception of two transfer pumps, the pulp washer described below is the only item of interest from a lubrication standpoint. The bleached pulp must be thoroughly washed to free it of chemicals before further processing. This is normally accomplished on continuous rotary washers consisting of a large partly-submerged, perforated drum which revolves slowly in a tank of the pulp. Vacuum within the drum carries the pulp to the top where it is continuously spray-washed to remove the chemicals. It is then removed from the cylinder.

The rotary pulp filter washer gears and trunnion bearings are lubricated by means of an oil bath or a sight-feed cup. A heavy cylinder oil is recommended for this service since the bearings and gears are always subjected to appreciable amounts of water. The discharge roll bearings are usually furnished with pressure grease fittings and a No. 2 consistency water resistant grease is recommended for use on these bearings.

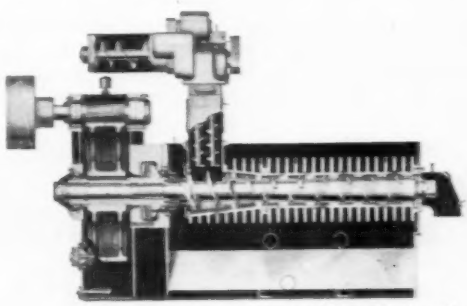
BEATER ROOM

All the processing steps, up to now, have dealt with the making and refining of pulp for subsequent use in paper manufacture. Papers are highly technical formulations of this cellulose pulp admixed with many other materials added to impart the desired characteristics to the final product. The paper industry is one of the largest consumers of chemicals. Paper making starts in the beater room where the previously prepared pulp and other constituents are mixed and further processed prior to feeding to the paper machines. The demand for maximum production and the introduction of new woods has brought about a radical change in beater room equipment. The *hollander beater* which operates batchwise and defibrates the pulp between a large revolving roll and bedplate has been largely replaced by high-speed continuous refiners. The beater serves a three-fold purpose — (1) to cut the fibers, (2) to separate "bundles" of fibers in the stock, and (3) to impart fiber flexibility.

The *beater*, or *hollander*, consists of an open top wood or steel rectangular tank approximately 25′ x 11′ x 3½′ with semicircular ends and containing a longitudinal center partition ("midfeather") which forms a circular trough. The beater roll is mounted directly over a bedplate on one side of the tank. The entire circumferential face of the beater roll as well as the bedplate are made up of a large number of knives. As the roll revolves over the bedplate, a tearing and cutting of the pulp fibers takes place and this constitutes the first step in pulp refining. Fine adjustments between the roll and bedplate control the degree of refining occurring in the beater.

The beater rolls are very heavy and rotate at approximately 100 RPM. They are supported on plain bearings which are lubricated with either "block" grease or a high viscosity oil. Due to the severe loads on the bearings, the lubricant must protect against wear and corrosion which have such a detrimental effect on the operation of plain bearings. Another piece of equipment used to refine stock is illustrated in Figure 12.

In line with trends in other industries, the beaters are being replaced by high capacity, more economical, continuous *refiners*. There are several designs



Courtesy of Bauer Brothers Co.

Figure 12 — "Pressafiner" pump refiner.

Courtesy of E. D. Jones & Sons Co.

Figure 13 — Battery of eight "jordan" pulp refiners.

of these units in service. They all depend upon serrated or knifed surfaces revolving at high speeds and close tolerances to produce the desired cutting and defibrating. Their design includes means of finely adjusting the space between the working surfaces to accommodate the handling of varying stocks.

The *jordan engine* is the most common of these final stock refining units and a battery of eight is shown in Figure 13. A *jordan* consists of a conical plug which revolves at high speeds within a hollow cone or shell. The surface of the plug is fitted with longitudinal steel knives held in place with wooden fillers. A similar set of knives is set around the interior of the shell. The stock is pumped into the small end of the cone and discharges at the large end. It is normal practice to have a battery of these units connected in series with by-pass arrangements to obtain the desired refining, and to enable cutout of any machine for repairs when necessary.

All these units are motor driven and have either oil or grease lubricated anti-friction bearings. Proper sealing is vital and dictates the use of water resistant greases when grease lubrication is required. Grease lubricated jordan bearings have a tendency to run very hot due to their high speeds and thrustloads. The use of an excessive amount of grease may contribute materially to this condition and the temperature can frequently be reduced to normal by less frequent application of smaller amounts of grease.

The material from the *jordans* goes to the stock chests where agitation holds the solid material in uniform suspension for charging to the paper machine. Consistency regulators control the consistency of the "stuff" fed to the paper machine to within the very narrow tolerances which are necessary for the formation of an uniform sheet. All the operations up to this point have culminated in the formation of "stuff" which contains approximately 1.0 per cent solids and 99.0 per cent water. The process of paper making is now at the midway point; and the subsequent operations on the paper machine are directed toward the elimination of water, so that the final sheet will contain approximately 93 per cent solids and 7 per cent water. Dehydration is not the only objective in the final operations as it is also necessary that the machine operations result in a paper having the required weight, strength, and surface characteristics.

PAPER MACHINES

There are many designs of paper machines in use today, depending on the type of paper to be made and the desired tonnage production. For the sake of simplification, these can be divided into two classes based on the method of sheet formation. These are the "Fourdrinier" machine which was invented in France in 1799 and the "Cylinder" machine invented in this country ten years later. The Fourdrinier was first used in this country in 1836 and one of its huge modern descendants is illustrated schematically in Figure 14. It is used in the manufacture of all our newsprint, kraft, and bookpapers. The cylinder machines were less extensively used in the past but are rapidly increasing in number as a result of increased demands for the heavier products such as wallboard and roofing felts for which they are adapted.

In any paper mill, it is the paper machine that is considered the "heart" of the operation and for which the numerous other pieces of equipment serve as auxiliaries. Some modern paper machines are approximately 250 feet long and cost in the neighborhood of seven million dollars. The economy of the entire plant is dependent upon the paper ma-

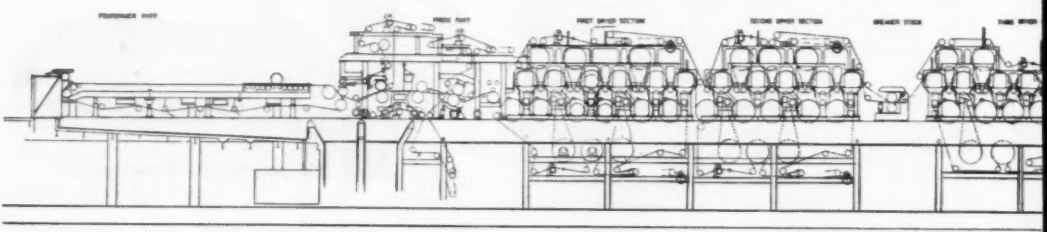
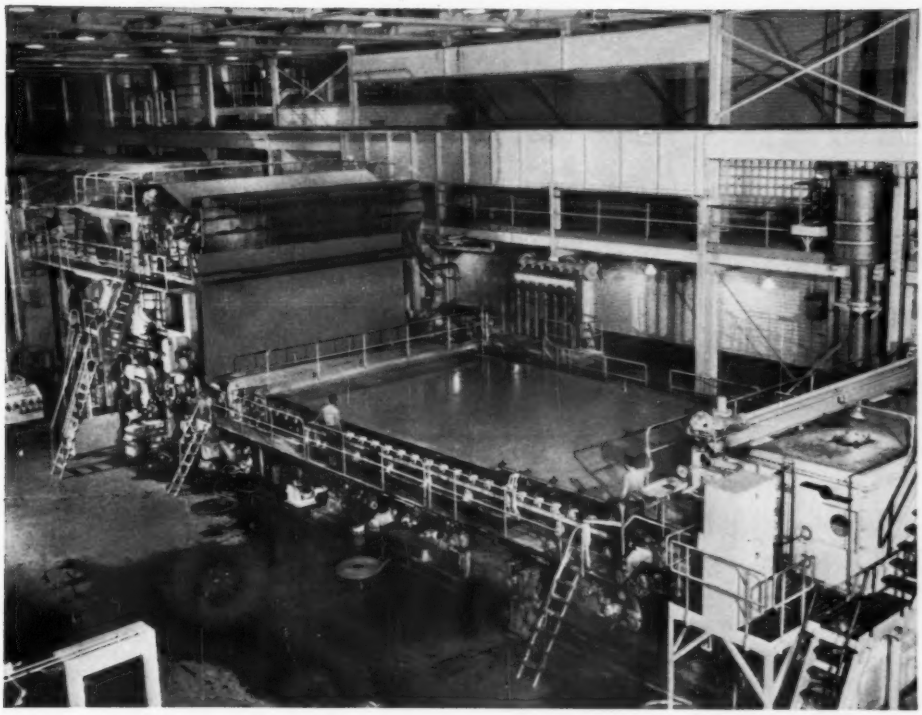


Figure 14 — Fourdrinier



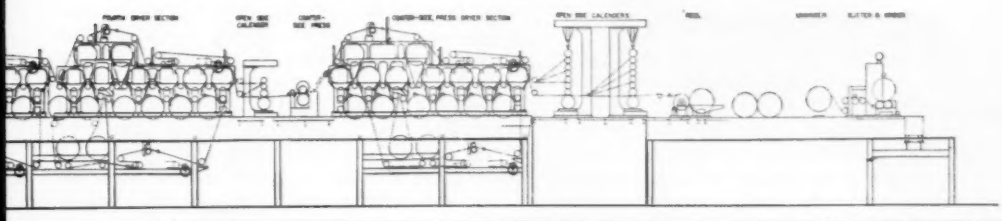
Courtesy of Great Northern Paper Co.

Figure 15 — Fourdrinier and press sections, 290" newsprint machine.

chine running practically continuously, except for scheduled shutdowns, and turning out paper to its maximum capacity. The greatly increased demands for paper and paper products have had definite effects upon the operation of existing paper machines (some of which are fifty years old) and the design of new machines. All changes have been directed towards keeping the machines running longer and at greater speeds to satisfy the demand for more paper. The more important of these changes are:

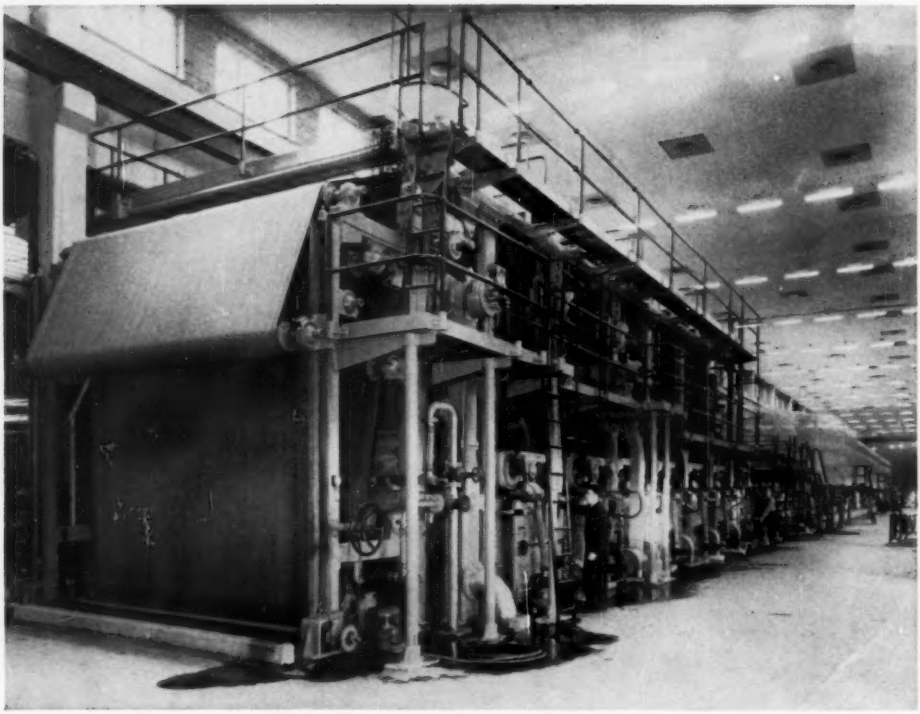
1. Use of anti-friction bearings on all rolls
2. Use of higher steam pressures (up to 150 p.s.i.) to increase the drying rate
3. Use of improved oils having sufficient load carrying capacity at the higher temperatures to insure bearing protection under the more severe operating conditions
4. Construction of wider machines to produce paper over 25 feet wide
5. Removable Fourdrinier sections on which wires can be changed in one-third the time as compared to the stationary-type Fourdrinier

The only way to really appreciate the tremendous improvements made in paper machines during the past fifty years is to compare the newest and oldest machines in some of our mills today.



paper machine.

Courtesy of Rice Barton Corp.



Courtesy of Black-Clawson Co.

Figure 16 — Wet end of cylinder-type paper machine.

CYLINDER MACHINES

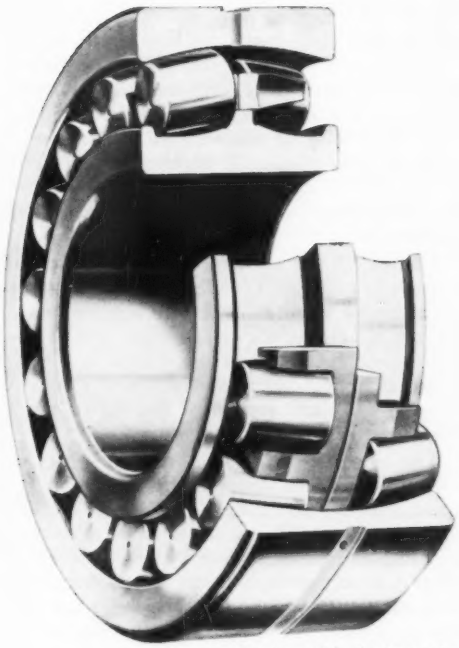
The cylinder machine forms the sheet on a wire-covered cylinder which revolves in a vat of paper stock. The solids collect on the wire cloth as the water is pulled through by vacuum within the drum. The sheet is picked up on top of the cylinder by a long *wet felt* and moved through suction rolls. A series of squeeze rolls and press rolls effect water removal, followed by a series of steam-heated dryer rolls for the final drying. Cylinder machines are very flexible in design since several cylinders may be used in series, each of which adds another layer of fibers to the sheet. Products varying in thickness up to one-half inch can be made on these machines.

FOURDRINIER MACHINE

In considering the operation and lubrication of a Fourdrinier machine, it is customary to consider it as consisting of two distinct sections — the "wet end" and the "dry end." At the "wet end," pictured in Figure 15, dehydration results from filtration by the wire, vacuum at the suction boxes, and pressure at the "couch" and "press" rolls. Figure 16 presents the wet end of a different type of machine. At this point in the operation, the solid content has increased from one to approximately thirty per cent. The embryo paper leaving the press rolls enters the "dry end" of the machine where further dehydration is effected by evaporation caused by passing the sheet over a great number of large steam-heated rolls.

Wet End Operation

The formation of the sheet from the *stuff* (dilute fiber slurry) in the stock chest is a process of dehydration which takes place in three stages — at the fourdrinier, press section, and driers. The greatest percentage of water reduction occurs at the fourdrinier section where the *stuff* is run onto the *wire* which is an endless copper, bronze or stainless steel screen which travels continuously around a series of rolls at a speed set for the machine. The stock chest is provided with mechanical agitators which is necessary to prevent variations in the finished paper. The *wire* is carried on a large number of closely spaced table rolls which maintain it in a single plane in order to insure uniform water removal over its entire area which is required to produce an uniform sheet. In order to assist the water



Courtesy of The Torrington Co.

Figure 17 — Spherical-roller bearing for dryer roll.

in passing through the wire and also to orient the cellulose fibers for the formation of a stronger sheet, the wire section is subjected to a very definite vibratory action. After the wire has passed over the table rolls, it passes over suction boxes in which reduced pressure is maintained to promote additional dehydration of the sheet. The water which drains from the sheet in the fourdrinier falls into a tiled tank, called a "saveall" from which it is pumped for reuse.

Couch and Press Rolls

After passing over the suction boxes, the wire with the web of paper passes between *couch rolls* where it is squeezed to remove more water. The rolls are normally two to three feet in diameter with the bottom roll being driven by an electric motor. The couch rolls drive the entire fourdrinier section. Considerable pressure is placed upon the top roll by means of levers and weights. Sufficient water is squeezed from the paper by the couch rolls so that the web will now support its own weight. At this point the wire is separated from the paper and returned to the *breast* roll over return rolls located below the table rolls.

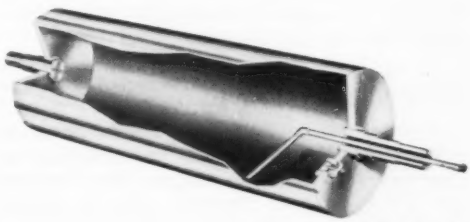
Wet End Lubrication

The water condition which is prevalent in so much paper mill equipment is especially serious at the fourdrinier and offers a challenge to the lubrication engineer. All the rolls, which are grease lubricated, operate under very wet conditions and it is essential to use a grease having low water-absorbing characteristics. It is also necessary that the grease does not thin out due to water absorption with a resultant loss in lubricating ability and the possibility of severe leakage. This is especially true in the lubrication of the ball-type table-roll bearings. The table rolls are driven by the wire moving across their tops and any resistance to rotation results in a drag on the wire which causes wear and short wire life. This is costly due both to the high cost of replacement wires and to the machine downtime required to make the change. The normal calcium soap greases previously used for lubrication of the fourdrinier rolls have almost universally been replaced with the multipurpose lithium soap greases. Newly developed calcium soap greases are being introduced into this service due to their lower water absorption characteristics which result in less change in consistency, less leakage, and less frequent lubrication intervals.

Dry End Operation

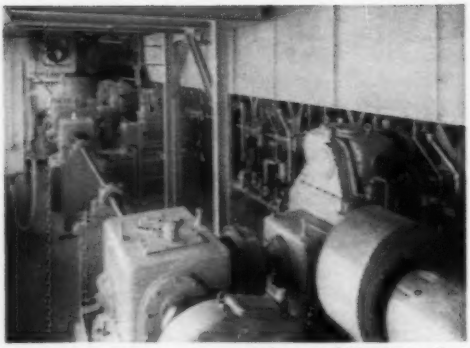
The dryer section of a modern fourdrinier machine consists of as many as one hundred steam heated *dryer rolls* each about five feet in diameter and twenty-five feet long. These rolls weigh approximately eighteen tons each and are carried by heavy journals and double roller self-aligning bearings like that shown in Figure 17 and operating at speeds as high as 150 RPM. The rolls are geared together at their journals in order to synchronize their rotation, an absolute necessity. High pressure steam enters and leaves each dryer roll through specially designed steam joints in the journals on the drive side of the unit shown in Figures 18 and 19. In addition to the paper dryers there are similar rolls for drying the felt and a greater number of small idler rolls over which the felt is threaded in the drying operation.

The paper web coming from the press rolls of the



Courtesy of the Lukens Steel Co.

Figure 18 — Dryer roll.



Courtesy of Rice Barton Corp.

Figure 19 — Differential drives on dryer rolls.

Fourdrinier is transferred to the dryer felt which carries it through the dryer section. At this point the water content has been reduced to approximately seven per cent. The final step consists of running the paper through one or more calender stacks depending upon the surface finish desired. The calender stack consists of seven or more steel rolls mounted vertically in a housing. The two bottom rolls and the top roll are larger than the intermediate ones. The whole stack is driven by friction on the bottom roll.

There are two modifications of the above dryer section which are worthy of mention at this time. The "Yankee" machine has one very large dryer, considerably over ten feet in diameter, instead of several smaller dryers. The capacity of this unit is limited by the drying capacity of the dryer. It produces an excellent shiny surface to one side of the paper which cannot be obtained by the typical calenders. Paper napkins, towels and tissues are made on a Yankee machine.

The "Minton" dryer is the second modification. In this unit the entire dryer section including rolls and felt is enclosed in an airtight chamber. Seals on either end of the chamber permit the wet paper to enter and the dry paper to leave without breaking the vacuum maintained in the chamber. The use of vacuum permits drying at lower temperatures and the steam consumption is considerably lower. These benefits are offset by the higher initial costs.

Dryer Bearing Lubrication

There are many paper machines in operation today in which the dryer sections have plain bearings lubricated with block-type grease. These operate over a wide range of temperatures and frequently considerable experimenting is necessary to find a grease having the correct melting point and consistency to perform satisfactorily. Block greases having too low a melting point will melt and feed too rapidly while those having too high a melting point will glaze and carbonize and provide inadequate lubrication. Many other old and slow machines have hand or wick-fed oil-lubricated plain bearings. These plain bearing machines are in the minority as far as paper tonnage is concerned. In the design of our present high speed machines the plain bearings have given way to self-aligning double roller bearings.

The lubrication of dryer anti-friction bearings (Figure 17) and gears is affected by the continuous circulation of the oil from a central reservoir to each bearing and gear of the dryer section. The oil flows from these bearings and gears into lines which return it to the central system where extraneous material and water are settled and the oil filtered before it is returned to the dryer.

The lubrication of the anti-friction dryer bearings under current operating conditions in high speed machines has offered a considerable challenge to the petroleum industry. The straight mineral oils and turbine type oils which provided satisfactory lubrication for these bearings at low speeds and temperatures were found inadequate when dryer steam pressures were increased to speed paper production. An intensive study of bearing failures in the field coupled with subsequent laboratory investigations clearly indicated that the failures resulted from inadequate rust prevention and load carrying capacity of the circulating oils.

CIRCULATING OIL CHARACTERISTICS

The circulating oil systems for modern high speed paper machines are very similar to those in other industrial operations in that they supply the required amount of clean lubricant to bearings

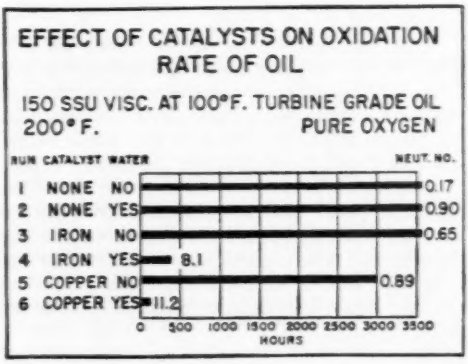


Figure 20 — How the presence of metals and water can increase oil oxidation.

and gears to provide satisfactory lubrication and insure continuous operation.

The straight mineral oils originally used in dryer bearing circulating oil systems left considerable to be desired since they did not insure against corrosion due to water and during extended runs left a carbonaceous deposit on the bearings which had to be manually removed at frequent intervals. They were found to be unsuitable for the lubrication of bearings operating under high loads and at high speeds and temperatures. They lacked the necessary load carrying capacity at the higher operating temperatures. An epidemic of bearing failures was experienced on kraft machines before it was realized that the higher bearing temperatures resulting from increasing dryer steam pressures from 75 to 125 p.s.i. required a different type of circulating oil. This is especially true for the drive side bearings where the steam enters and leaves the dryer through a hollow journal (Figure 18) and gives rise to higher bearing temperatures.

Essential Properties

Since oils in this service are subjected to relatively high temperatures, high loads and heavy water contamination, a lubricant must have several necessary facets to perform satisfactorily. The prime requirements are as follows:

The *oxidation stability* of circulating oils in this service is of paramount importance since large volumes are involved and frequent replacement due to oxidation, which impairs the usefulness of the oil, is uneconomical. There are several factors that should be considered in order to insure optimum service performance in respect to oxidation.

The original selection of an oil having good oxidation resistance is mandatory. The petroleum research chemists in their development of oils for specific purposes have recognized for years that oil oxidizes in service and that the extent of oxidation is dependent upon the service condition to which it is exposed. In order to improve the resistance to oxidation of normally refined lubricating oils, oxidation inhibitors are added. The inhibitor used must be selected to retard oxidation under the conditions to which the oil is to be exposed and at the same time have no detrimental effect on other essential properties of the oil.

The temperature to which a paper machine circulating oil is exposed is the most important single factor affecting its oxidation. Bulk oil temperatures in the circulating system are not nearly as significant as the bearing surface temperatures to which the oil is exposed in thin films under conditions conducive to oxidation. The oil passing through the large self aligning double roller bearings is carried around the bearing races by the rollers in thin films constantly in contact with moisture saturated air. This is especially true in the drive side bearings which are mounted on hollow journals through which high pressure steam is fed to the dryers and condensate returned.

There are no reliable data available as to bearing surface temperatures but these will vary over a considerable range from newsprint and tissue machines operating at low steam pressures to those on Kraft machines where 150 p.s.i. steam pressure and 50°F. superheat may be used. It is reasonable to assume that bearing temperatures increase with steam pressures at an increasing differential due to radiation losses. Since oil oxidation is a chemical reaction and increases rapidly with temperature, it is readily apparent that more heat resistant circulating oils are required in the Kraft machines than the newsprint and tissue units.

A second factor which increases oil oxidation is the presence of catalysts. Certain metals, especially copper, accelerate oxidation and consequently should be held to a minimum in circulating oil systems. Copper tubing which can be easily manipulated to make oil feeder and return lines to the bearings has been used in this service with detrimental results. The acidic constituents in the oil after a period of use react with the copper to form oil soluble copper soaps which hasten further oil oxidation. Finely divided iron wear particles from gears and other rubbing mechanical parts has an analogous effect. This catalytic effect of copper and iron is further accelerated by the presence of moisture.

A third factor having a definite effect on the service life of a circulating oil is the volume of oil in the circulating oil system and the rate of make-up oil required monthly due to losses resulting from leakage which is inherent in all machines to a widely varying degree. The volumes vary from 1,000 to over 14,000 gallons, and the annual rate of make-up ranges from 14 per cent to well over 100 per cent of the volume in the system.

As illustrated in Figure 21 it is obvious that the oil in those machines having high make-up rates will be slower to show the effects of oxidation under given operating conditions than those with low make-up rates due to the increased quantities of new oil that is required to maintain the original volume. Since the volume of make-up for any machine is relatively constant, it is further evident that the oil in those units having small oil systems is replaced faster than in those having larger volumes.

The use of detergent-dispersant circulating oils corrected all the shortcomings of straight mineral oils and have been accepted as standard for this

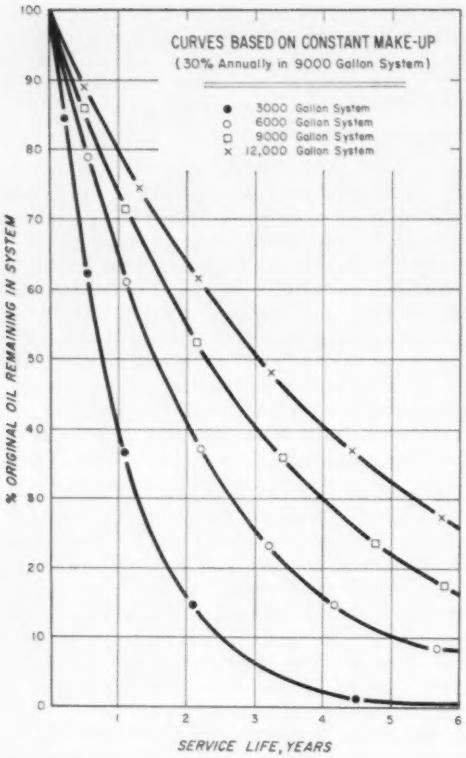

CURVES BASED ON CONSTANT MAKE-UP
(30% Annually in 9000 Gallon System)
3000 Gallon System
6000 Gallon System
9000 Gallon System
12,000 Gallon System
% ORIGINAL OIL REMAINING IN SYSTEM
SERVICE LIFE, YEARS

Figure 21 — Effect of Circulating Oil Replacement Rate on Oil Service Life.

service. This type of oil is characterized by:

1. Increased load carrying capacity at high temperatures which insures against bearing failure
2. Greater oxidation resistance which insures extended oil life at the higher temperatures
3. Excellent rust protection which minimizes bearing corrosion
4. Detergent and dispersant qualities which prevent accumulation of hard carbonaceous deposits in the bearings and saves many hours of machine downtime formerly required to remove these deposits

There are two very important factors in the lubrication of high temperature dryer bearings that must be given careful consideration to insure trouble free operations. These relate to the increased temperatures which accelerate oil oxidation and to the detrimental effect of water on some detergent-dispersant additives.

Increased bearing temperatures promote increased oxidation for any type of oil. This can be often handled effectively by maintaining a maximum oil flow rate to the bearings. It is essential that the circulating oil systems be designed to insure an ample flow rate to each bearing and that readily accessible flow control mechanisms be provided to insure an uninterrupted flow. This is important not only as it concerns oil oxidation but for the cooling effect on the bearings.

It must be recognized that the detergent-dispersant oils required for high temperature dryer bearing lubrication are prone to be more sensitive to water than straight mineral oils. Unless properly formulated they may not separate water as rapidly as desirable. Excessive water entry may also cause additive depletion. Water contamination must be minimized by proper design and maintenance procedures.

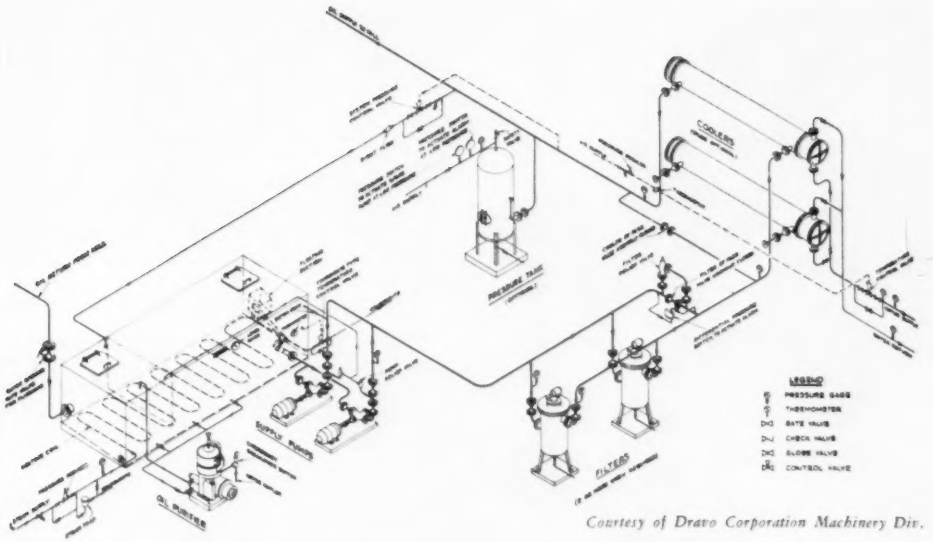
Oil Reconditioning

The circulating oil system of a modern paper machine consists of a clean oil tank from which the oil is continually pumped under pressure (approximately 35 p.s.i.) through a header along each side of the dryer sections from which it is fed at a controlled rate to the individual bearings and gears. The oil overflows the bearings and gears into a return oil header which returns it to the central supply tanks where it is settled and filtered prior to recirculation. In addition to lubricating the dryer section, this oil may also be used in the power input gear cases and the calender stack to which it is fed through separate circulating lines.

Before being recirculated, the oil is normally subjected to three stages of purification. In the settling tank, any water which may have been picked up by the oil has a chance to settle out and is removed through draw-off lines. Upon overflowing the settling tank the oil is subjected to gravity filtration through filter fabrics which retain any suspended solid material. In recent years an additional set of filters has been placed on the circulating oil pump discharge to remove any very fine material that may not have been previously removed.

With the introduction of detergent type oils into dryer circulating oil systems it has been found that the cotton-wool filter fabrics were subject to rapid deterioration. Experiments have shown that considerably longer filter life is obtained when synthetic fabrics such as dynel, dacron or orlon are used. Some of the larger circulating oil systems have as many as ninety filters and considerable savings are possible by using such synthetic fabric filtering media.

Active clay-type filters should not be used in these systems since they remove the additives in the oils.



Courtesy of Dravo Corporation Machinery Div.

Figure 22 — Schematic of typical paper machine circulating oil filter system.

The 10,000-15,000 gallon circulating oil systems used on some of the earlier high temperature machines are giving way to much smaller systems of 4,000-6,000 gallon capacity which are proving themselves to be very adequate. Such a system is diagrammed in Figure 22. The following factors favor the smaller systems:

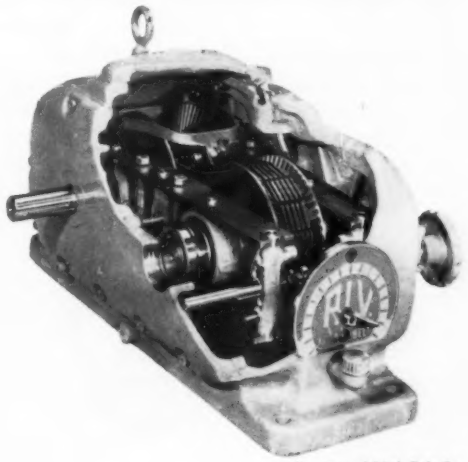
1. Lower initial oil costs

2. Each machine has a "constant" volume make-up oil requirement. On a percentage basis this increases as the size of the system decreases. Consequently the make-up oil has a greater renewing effect on the oil in smaller systems than in the larger ones.

3. It must be recognized that oils in paper machine systems will eventually have to be replaced for any one of a number of reasons. This will occur more frequently in high temperature machines than in those operating under more moderate conditions. With the high value assessed against machine downtime at the present time, it is wise to consider scheduled periodic oil changes rather than risk downtime due to lubrication difficulties. The economics of changing out small systems as compared to large ones is evident.

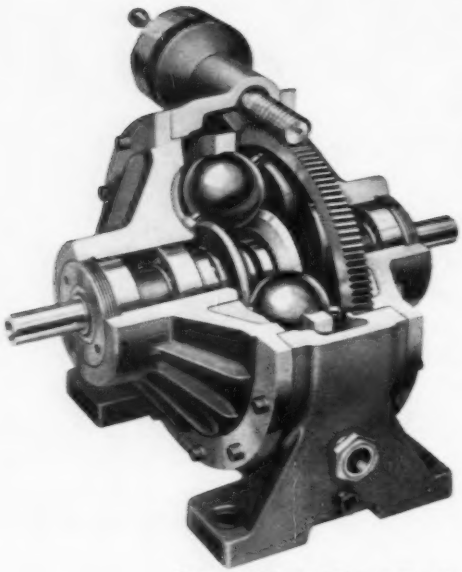
DRIVES

The speed of the paper through the press sections and dryer sections must be closely synchronized to eliminate breaks in the sheet. As shown in Figure 19 these units are driven by a common shaft through gears of varying design with variable speed regulators. These gears are normally lubricated by the same circulating oil system that serves the dryer bearings. In some cases these gear cases are lubricated by a separate circulating oil system in which a mild extreme pressure oil is used. Hypoid gears have been used in these drive units and dictate the use of an active type extreme pressure lubricant.



Courtesy of Link-Belt Co.

Figure 23 — Adjustable—speed roll-drive unit.



Courtesy of Cleveland Worm & Gear Co.

Figure 24 — Adjustable-speed roll-drive unit.

Variable speed regulators like those in Figures 19, 23 and 24 are bath lubricated with straight mineral oils. Compounded oils should not be used in this service due to the possibility of deposit formations which would lower the sensitivity of the unit.

Again as shown in Figure 19 the dryer rolls are connected through a gear train consisting of spur or helical gears, or by means of roller chains, to synchronize their rotation and maintain the proper tension passing between them.

In most modern machines these gear trains and chains are enclosed in oil-tight housings and are lubricated by a circulatory system which is similar to, or is the same system which lubricates the bearings. Such a system assures that an adequate supply of clean protective lubricant is provided at all times. The same characteristics of the lubricant for the bearings are highly desirable for the lubrication of these gears and chains in order to assure minimum wear, protection against rusting and freedom from deposits.

MAINTENANCE

The use of premium lubricants will go far to assure trouble free operations in integrated operations as large as our modern paper mills. However, lubricants cannot be expected to compensate for mechanical defects such as worn bearings or gears, shaft misalignment, faulty seals, etc. It is necessary to have a well organized maintenance program to correct mechanical dificiencies and then apply the correct lubricants at recommended intervals to insure good performance. Reducing the number of oils and greases at a mill to a minimum consistent with the lubrication requirements is one of the most important steps toward insuring the use of the correct product.

SUMMARY

The role played by the lubrication engineers and oilers in our paper mills is more important today than ever before. Our faster machines operating under higher loads and at higher temperatures require not only premium lubricants but also a thorough maintenance program to insure their proper application.

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Photo courtesy The Pusey and Jones Corporation

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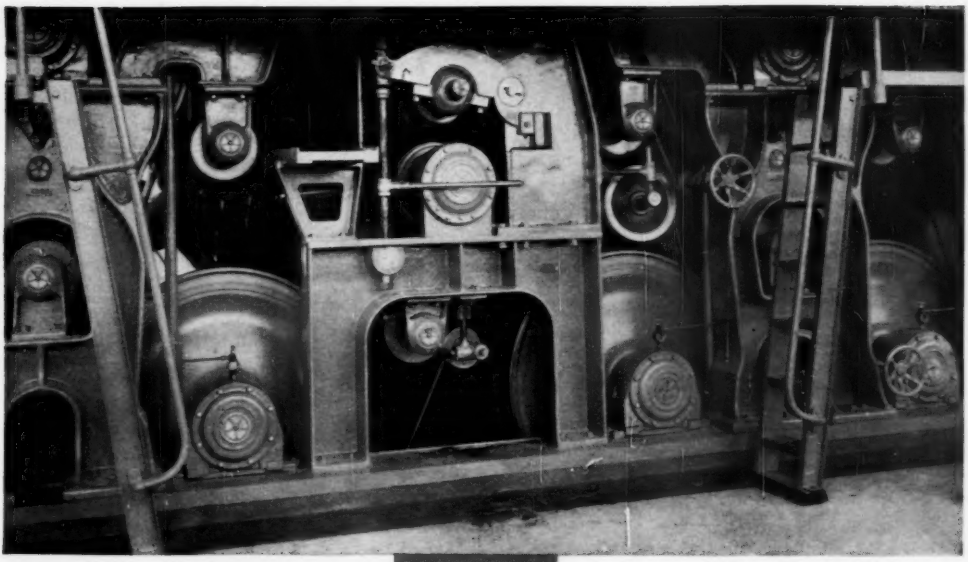

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2. It Stays Stable – Oxidation stability means long dependable service under severe conditions of heat or moisture.

3. It Prevents Rust and Corrosion—The entire system remains rust and corrosion-free, whether machines are running or idle.

4. It Keeps Machines Clean – Full detergent and dispersive properties means lines and bearings stay free of carbon, dust and deposits. Bearings run smoother, longer.

5. It Doesn't Sludge – Texaco Paper Machine Oil HD separates from water quickly and easily.

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